Associations Between Physical Activity and Depressive Symptoms by Weight Status Among Adults With Type 2 Diabetes: Results From Diabetes MILES-Australia.

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Abstract

Background: To examine associations between physical activity (PA) and depressive symptoms among adults with type 2 diabetes mellitus (Type 2 DM), and whether associations varied according to weight status.

Methods: Diabetes MILES – Australia is a national survey of adults with diabetes, focused on behavioral and psychosocial issues. Data from 705 respondents with Type 2 DM were analyzed, including: demographic and clinical characteristics, PA (IPAQ-SF), depressive symptoms (PHQ-9), and BMI (self-reported height and weight). Data analysis was performed using ANCOVA.

Results: Respondents were aged 59±8 years; 50% women. PA was negatively associated with depressive symptoms for the overall sample (η_p^2= 0.04,p<0.001) and all weight categories separately: healthy (η_p^2 0.11, p=0.041,), overweight (η_p^2= 0.04, p =0.025) and obese (η_p^2=0.03, p=0.007,). For people who were healthy (BMI 18.5-24.9) or overweight (BMI 25-29.9), high amounts of PA were significantly associated with fewer depressive symptoms; for adults who were obese (BMI $\geq$ 30) however, both moderate and high amounts were associated with fewer depressive symptoms.

Conclusions: PA is associated with fewer depressive symptoms among adults with Type 2DM, however the amount of PA associated with fewer depressive symptoms varies according to weight status. Lower amounts of PA might be required for people who are obese to achieve meaningful reductions in depressive symptoms compared to those who are healthy weight or overweight. Further research is needed to establish the direction of the relationship between PA and depressive symptoms.

Introduction

The associations between physical activity (PA) and depressive symptoms have been examined extensively in the general population and show that PA is associated with fewer depressive symptoms[1,2]. There is also emerging evidence in the general population that the associations between PA and depressive symptoms vary according to whether the person is of healthy weight, overweight or obese [3]. These associations, however, have not been explored thoroughly among people with Type 2 D [4,5].

Diabetes is a global epidemic [6], projected to affect up to 3 million Australians over the age of 25 years by 2025 [7]. Around 85% of diabetes is accounted for by Type 2 diabetes mellitus (Type 2 DM) [7]. People with Type 2 DM are two to three times more likely to experience depressive symptoms compared to the general population [8,9]. In addition to being associated with lower physical and mental functioning [5,10] and lower quality of life [11], depressive symptoms are also associated with increased/higher risk for suboptimal glycaemic control, diabetes-related complications [12], increased/higher health service use [10], and higher mortality rates [13]. Examining factors, including PA that might be associated with higher or lower levels of depressive symptoms among people with Type 2 DM is vital to inform healthcare practices and the development of tailored interventions.

PA is a central component of the self-management regimen for people with Type 2 DM, and thus associations with depressive symptoms are likely to be more complex than for other population groups [14]. A small body of research has shown an inverse association between depressive symptoms and participation in PA among people with Type 2 DM [4,15,16]. These associations require further investigation, specifically, including the role of weight status. An

examination of the associations between PA, depressive symptoms and weight status among adults with Type 2 DM is needed because people with Type 2 DM have a high incidence of overweight and obesity [17], and a recent study from the Diabetes MILES-Australia dataset (also used in the current study) showed that higher body mass index (BMI) is associated with greater symptoms of depression among people with Type 2 DM [12].

The purpose of this study was to provide further understanding of the associations between PA, depressive symptoms and weight status in Type 2 DM. Specifically, the aims of this study were to assess, in a large, population-based sample of adults with Type 2 DM: (1) the associations between PA and depressive symptoms; and (2) whether associations between PA and depressive symptoms varied according to weight status.

Methods

Study Design

Data was collected in 2011 as part of the Diabetes MILES (Management and Impact for Long-term Empowerment and Success) – Australia study. Diabetes MILES – Australia is a large, national survey of adults living with Type 1 or Type 2 DM, which aims to examine the psychological, behavioral and social factors relevant to living diabetes. The study protocol and sample characteristics are described in detail elsewhere [18].

Briefly, the Diabetes MILES – Australia survey was distributed by post to a random sample of 15,000 registrants of the National Diabetes Services Scheme (NDSS), and made the survey available online. Eligibility criteria were living with Type 1 or Type 2 DM, aged 18 to 70 years, living in Australia, and able to complete the survey in English without assistance. In

total, 3,338 eligible respondents completed the survey. Several survey versions were used in order to tailor content to diabetes type and treatment, and to reduce respondent burden (not all scales/items appeared in all versions). .

Ethics approval was granted by the Deakin University Human Research Ethics Committee (2011-046).

Measures

Demographic and Clinical Variables

Demographic variables included gender, age, relationship status, highest level of education, country of birth, and annual household income. Clinical data extracted for this study were diabetes duration, insulin treatment (yes/no), co-morbidities and height and weight (for calculation of BMI). For the co-morbidities item, respondents were asked if they have a range of health conditions, for example, coeliac disease, fatty liver disease, heart disease / heart attack, high blood pressure (hypertension). The number of comorbidities that respondents reported was summed to represent the total number of comorbidities. All data were collected by self-report.

Depressive symptoms

Depressive symptoms were assessed using the Patient Health Questionnaire-9 (PHQ-9), which is the depression module of the self-administered version of the PRIME-MD diagnostic instrument for common mental disorders. Respondents rated their experience of each of the nine DSM-IV criteria (i.e. depressed mood or irritable; decreased interest or pleasure in most activities; significant weight change or change in appetite; change in sleep; change in activity; fatigue or loss of energy; guilt/worthlessness; diminished ability to think

or concentrate; suicidality) as "0" (not at all) to "3" (nearly every day) [19]. Item scores were summed to form a total score (range: 0-27), with higher scores indicating higher levels of depressive symptoms. Total scores of ≥10 indicate moderate-to-severe depressive symptoms [19]. The PHQ-9 has been validated in a range of population groups [19-21]. For example, in a study of 6,000 patients, increased PHQ-9 depression severity was associated with a substantial decrease in functional status on all 6 Short-Form General Health 20 subscales, and increases in symptom-related difficulty, sick days, and health care utilization. In a study of 580 patients, where scores on the PHQ-9 were compared with independent structured mental health professional interviews, a PHQ-9 score ≥10 had a sensitivity of 88% and a specificity of 88% for major depression[19]. Among people with diabetes, , the PHQ-9 was an efficient and well-received screening instrument for major depressive disorders in a sample of patients in a specialized outpatient clinic [22]. For the current study, total score for depressive symptoms was the outcome variable.

Participation in physical activity

PA was assessed using the International Physical Activity Questionnaire Short Form (IPAQ-SF) [23]. The IPAQ-SF encompasses PA across all domains (including leisure, work and household chores) at three intensity levels: 1) vigorous, 2) moderate, and 3) walking. Studies of the measurement properties of the IPAQ across 12-countries demonstrated that the IPAQ instruments have acceptable measurement properties, at least as good as other established self-reports. IPAQ-SF had fair to moderate agreement with accelerometer-measured physical activity (pooled r = .30) and repeatability was at an acceptable level, with 75% of the correlation coefficients observed above 0.65 and ranging from 0.88 to 0.32[23]. The IPAQ-SF has also been used in other studies of adults with Type 2 DM[24]. Data were cleaned according to the data processing rules provided by the IPAQ developers [25].

Amount of PA was categorised as 'high', 'moderate' and 'low', consistent with the IPAQ-SF guidelines. These categories incorporate total metabolic equivalent (MET)/minutes per week as well as the number of days/sessions of PA. Total MET minutes were calculated by multiplying the minutes per week of walking, moderate-intensity PA and vigorous-intensity PA by 3.3, 4.0 and 8.0, respectively. The criteria for the three levels take into account that the questions in the IPAQ assess PA in all domains of daily life, resulting in higher median MET-minutes estimates than those estimated from leisure-time participation alone. The 'high' category represents a minimum of one hour moderate-intensity activity over and above the basal level of activity daily, or at least 30 minutes of vigorous-intensity activity over and above basal levels daily (basal activity was considered to be equivalent to approximately 5000 steps per day).. This level is equivalent to population targets for health-enhancing PA when multi-domain instruments, such as IPAQ, are used [25]. The 'moderate' category is defined as doing some activity, more than the low active category, and is equivalent to half an hour of at least moderate-intensity PA on most days. The 'low' category is defined as not meeting any of the criteria for either of the previous categories [25].

Body Mass Index (BMI)

BMI was calculated using respondents' self-reported weight, in kilograms, divided by the square of their self-reported height, in metres. BMI was then categorised based on World Health Organisation recommendations, with a BMI of 18.5-24.9 being considered healthy weight; 25-29.9 considered overweight; and ≥30 considered obese.

Data Analysis

The present study used data from a randomly selected sub-sample of participants with Type 2 DM who received the MILES-Australia survey version that contained scales/items about PA (*n*= 862). Analyses were performed on cases with valid and complete data and calculated scores for depressive symptoms if respondents had one or fewer missing data points on the PHQ-9 (with missing data imputed), otherwise the case was declared as missing. Cases with missing or invalid data for key variables (i.e. PA, BMI and depressive symptoms) were removed from the dataset prior to analysis; resulting in 705 valid cases). Demographic and clinical characteristics of cases included in the analysis were compared with those that were not included (due to missing or invalid data). There were no significant differences in any demographic or clinical characteristics examined except level of education (p =0.045), with those who had a university degree more likely to have valid answers for all items. For all other variables included in the analyses, missing data were minimal (0-1.0%), except annual household income and level of education, which had 5.2% and 5.7% of missing data, respectively.

Univariate analyses (Pearson correlation coefficients and t-tests) were performed to examine associations between demographics, clinical characteristics and depressive symptoms. The following variables were dichotomised: relationship status (partner versus no partner), level of education (less than university degree versus university degree and above), country of birth (Australian born versus born overseas), annual household income (≤$60,000 versus ≥$60,001). We included variables significant at 0.05 level in subsequent analyses.

For the main analysis, a series of ANCOVA analyses were conducted. First, an analysis of the associations between PA and depressive symptoms, unadjusted for covariates was

conducted. Following this, the overall association between amount of PA (low, moderate and high) and depressive symptoms, after controlling for covariates (i.e., co-morbidities, BMI, age [negative], income [negative], education level [negative], being single, and using insulin), were examined. A subsequent analyses according to weight status was conducted to determine whether being of healthy weight, overweight and obese had a modifying effect (BMI was not controlled for in these analyses and people who were underweight (n = 3) were not included in this analysis [26]). We used post hoc Bonferroni pairwise comparisons to examine significant differences between PA categories for analyses where a main effect of PA was significant. Mean differences reported are the adjusted mean differences after controlling for covariates in the models. Differences were considered statistically significant at $p < 0.05$.

Results

Sample characteristics

Respondents' age ranged from 23 to 70 years, with a mean of 59±8 years, and 50% of respondents were women (*n*=351). Most respondents were born in Australia (*n*=516, 73%), and were either married or in a de facto relationship (i.e., living with another person as a couple; *n*=510, 73%); 25% (*n*=166) reported a diploma/certificate as their highest level of education, and a further 19% (*n*=123) had completed secondary school; almost half reported an annual household income ≤$40,000 ($20,001-$40,000: *n*=163, 24%; ≤$20,000: *n*=147, 22%). Respondents had been living with Type 2 DM for 8.5±6.7 years; 32% (*n*=227) were using insulin to manage their condition and respondents reported a mean of 2.6±2.2 co-morbidities. See Table 1.

Table 1 here

Depressive symptoms, weight status and physical activity

Respondents' depressive symptom scores ranged from 0-27, with a mean of 6.6±6.0; 28% (*n*=195) of the sample had moderate-to-severe depressive symptoms. Respondents' BMI ranged from 14.6 to 94.3, with a mean of 32.6±7.8; 30% (*n*=214) of the sample were overweight and 59% (*n*=418) were obese. In terms of volume of PA, 29% (*n*=203) reported low levels of PA, 34% (*n*=237) reported moderate levels and 38% (*n*=265) reported high levels. See Table 2.

Table 2 here

Associations with depressive symptoms: univariate analyses

Depressive symptoms were associated positively with the number of co-morbidities (r = 0.382, $p<0.001$) and BMI (r = 0.14, $p <0.001$) and negatively with age (r = -0.13, $p =0.003$). T-test showed that higher depressive symptoms were associated with having a lower income (t= 2.441, $p=0.015$), a lower education level (t = 2.78, $p =0.006$), being single (t = 3.045, $p =0.002$), and using insulin (t = -3.27, $p = 0.001$). Each of these factors were included as covariates in subsequent ANCOVA.

Association between PA and depressive symptoms

The unadjusted analyses are shown in Table 3. The following results refer to the analyses that were adjusted for covariates. First, the overall association between PA and depressive symptoms were examined (see Table 4). The ANCOVA model was significant and explained

22% of the variance in depressive symptoms. PA was significant and had a medium effect size, controlling for other covariates in the model. There was a significant difference in depressive symptoms between low and moderate amounts of PA (mean diff = 1.87, p=0.002, 95% CI = 0.585 to 3.153) and low and high amounts of PA (mean diff = 2.55, p = <0.001, 95% CI = 1.268 to 3.824), however the difference between moderate and high amounts of PA was not significant (p = 0.531; 95% CI = -.525 to 1.878). These analyses show that moderate and high amounts of PA, compared to low amounts, were associated with fewer depressive symptoms.

Table 3 here

Table 4 here

For people of healthy weight, the ANCOVA model was significant and explained 29% of the variance in depressive symptoms. PA was significant after controlling for covariates and had a moderate effect size. There were significant differences in depressive symptoms between low and high PA (mean diff = 3.99, p=0.036, 95% CI = 0.199 to 7.773) but no significant difference between low and moderate amounts of PA (p=0.270, 95% CI = -1.261 to 7.102) or moderate and high amounts of PA (p=1.0, 95% CI = -2.500 to 4.631). These results suggest that high volumes of PAare associated with fewer depressive symptoms for people of healthy weight.

For people who are overweight, the ANCOVA model was significant and explained 16% of the variance in depressive symptoms. PA was significant after controlling for covariates and had a moderate effect size. There were significant differences in depressive symptoms

between low and high PA (mean difference = 2.79, p=0.024, 95% CI = 0.282 to 5.297) but no significant differences between low and moderate amounts PA (p=0.469, 95% CI = -1.029 to 3.979) or moderate to high amounts of PA (p=0.338, 95% CI = -0.677 to 3.305). Similar to people of healthy weight, these results suggest that, for people who are overweight, high amounts of PA, are associated with fewer depressive symptoms.

For people who are obese, the ANCOVA model was significant and explained 21% of the variance in depressive symptoms. PA was significant after controlling for covariates and had a medium effect size. There was a significant difference in depressive symptoms between low and moderate amounts of PA (mean diff = 1.786, p=0.034, 95% CI = 0.101 to 3.471) and low and high amounts of PA (mean diff = 2.055, p=0.012, 95% CI = 0.345 to 3.765) but not between moderate and high amounts of PA (p=1.0, 95% CI = -1.422 to 1.960). These results suggest that for people who are obese, moderate and high amounts of PAare associated with fewer depressive symptoms.

Figure 1 shows the associations between amount of PA and depressive symptoms for each weight classification (i.e., healthy weight, overweight and obese).

Figure 1 here

Discussion

This study examined associations between PA and depressive symptoms, controlling for a range of potential covariates, among a large, population-based, sample of adults with Type 2 DM. The findings suggest that associations between PA and depressive symptoms are complex; although PA was associated with fewer depressive symptoms, the amount of PA

that was associated with fewer depressive symptoms differed according to weight status. These findings present a range of avenues for future research in this area and have implications for the design of interventions that seek to reduce the burden of depressive symptoms and increase PA for people with Type 2 DM.

The present findings support previous research indicating that PA is associated with fewer depressive symptoms among adults with Type 2 DM [15,16]. The findings suggest that the amount of PA that is associated with lower depressive symptoms is equivalent to thirty minutes of moderate-intensity PA across all domains (e.g., active transport, household chores and leisure-time) on most days. Higher amounts of PA were not associated with additional declines in depressive symptoms above this level of participation. For the overall sample, after controlling for BMI, these findings suggested that PA, even at lower volumes than the recommended level for a physical health benefit [25], appears to be associated with fewer depressive symptoms. Other population-based research has shown that mental health benefits are associated with lower levels of PA than required for physical health [3,27]. Given that most adults with Type 2 DM find it challenging to meet PA guidelines, a lower level of participation is likely to be more achievable for the majority of the population, [28], which is an encouraging finding.

Interestingly, the findings of the current study indicate that the amount of PA associated with fewer depressive symptoms varied by weight status. For people in the healthy weight or overweight classification, a high amount of PA (equivalent to at least an hour or more of moderate-intensity activity, or thirty minutes of vigorous-intensity activity, on most days), was associated with fewer depressive symptoms. In contrast, for people in the obese classification, moderate amounts of PA were associated with fewer depressive symptoms and

there was no difference in depressive symptoms between moderate and high amounts of PA. These findings may, in part, be explained by the higher baseline depressive symptoms of people who are obese (mean depressive symptoms score for healthy, overweight and obese respondents was 5.5, 5.4, and 7.4, respectively) and a preference for lower intensity PA. Previously published findings from the Diabetes MILES – Australia study [12] showed that people with Type 2 DM who were severely obese were more likely to report moderate-severe depressive symptoms than matched controls (37% versus 27%). A systematic review of the effects of PA on depressive symptoms for people with chronic illness showed that PA had larger effects on depressive symptoms when baseline depressive symptoms were higher [29]. Also, people who are obese experience stigma due to their weight and this is related to PA avoidance [30]. Such stigma and feelings of self-consciousness are likely to be magnified when performing vigorous physical activities such as running and aerobics[31,32], and thus it is possible that more moderate levels of PA may be preferred by this group.

The cross-sectional nature of this study precludes assessment of the directionality of the association between PA and depressive symptoms. It is likely that the association between PA and depressive symptoms is bi-directional [33]; as well as the possibility of higher levels of PA reducing depressive symptoms, more depressive symptoms may lead to lower levels of PA. People with Type 2 DM and depressive symptoms are often physically inactive [5]. Symptoms of depression include a lack of motivation and energy and increased apathy [34] and may thus act as a barrier to participation in PA among people with Type 2 DM. A recent study of healthy older adults, however, found that those with depressive symptoms responded well to an exercise intervention that incorporated 14 face-to-face counselling sessions over 4 years designed to increase aerobic exercise.; half of those with depressive symptoms in the intervention group were able to maintain increased aerobic exercise during the four years of

follow-up[35]. Thus, interventions that reduce depressive symptoms might lead to increased PA in this group. Furthermore, the association between depression and increased risk of mortality among people with Type 2 DM [13] might be partly explained by low levels of participation in PA among people who are depressed.

As well as BMI, a range of other socio-demographic and clinical factors were associated with depressive symptoms in our sample. Socio-demographic factors including being single, being younger, having a lower income, lower education level and clinical factors including the number of comorbidities and being treated with insulin, were associated significantly with depressive symptoms. These associations have been identified in other studies of people with diabetes[36,37],[38], suggesting that it is important that they are considered in future studies that aim to examine the independent association between behavioural or psycho-social factors and depressive symptoms among adults with Type 2 DM. These findings also suggest that some population groups, such as those with lower socio-economic status, are more likely to experience depressive symptoms, and should be a focus of interventions that aim to reduce depressive symptoms.

Key strengths of this study are the large, population-based sample of adults with Type 2 DM and novel in-depth examination of the associations between PA, weight and depressive symptoms. The limitations of this study include the cross-sectional nature of the data, which means that causality cannot be implied by the findings. Self-report data were used to measure participation in PA as well as height and weight, which may result in social desirability bias. For large population-based studies, however, direct observation is not feasible and it is necessary to rely on self-report. Furthermore, the associations examined were less impacted by any self-report bias than would be the case if examining the effect of an intervention, the

measure of PA used in this study has adequate reliability and validity [23], and self-report height and weight has been shown to accurately identify weight categories[39]. We categorized PA according to the IPAQ-SF guidelines, however, a limitation of this approach is that these categories do not allow independent examination of the frequency or intensity of PA and future research should examine the impact of these on depressive symptoms among people with Type 2 DM. Limitations of the broader MILES study are also applicable to the current study and have been described in detail previously [18] .

In conclusion, this study advances current knowledge on associations between PA, weight status and depressive symptoms among people with Type 2 DM. The findings suggest that even moderate amounts of PA are associated with fewer depressive symptoms. Therefore, improving participation in PA may lead to decline in depressive symptoms, or a reduction in depressive symptoms may help to improve participation in PA. The role of weight status needs further examination in future studies to test the robustness of these findings concerning the levels of PA that are associated with fewer depressive symptoms among people in different weight categories.

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493 **Table 1: Demographic and clinical characteristics of sample**

	N	*Mean / n*	*SD / %*
Gender	700		
Women		351	50.1
Age	703	58.9	8.3
Relationship status	700		
Single		71	10.1
In steady relationship		7	1.0
Married/defacto		510	72.9
Separated		25	3.6
Divorced		64	9.1
Widowed		23	3.3
Education (highest level)	665		
No formal qualifications		67	10.1
School/intermediate certificate		96	14.4
High school/leaving certificate		123	18.5
Trade/apprenticeship		68	10.2
Certificate/diploma		166	25.0
University degree		95	14.3
Higher university degree		50	7.5
Household Income (annual)	668		
Up to $20,000		147	22.0
$20,001-40,000		163	24.4
$40,001-60,000		142	21.3
$60,001-100,000		128	19.2

$100,101-150,000		55	8.2
$150,001 or more		33	4.9
Country of birth	705		
Australia		516	73.2
Other		189	26.8
Diabetes duration - years since diagnosis	698	8.5	6.7
Diabetes management	700		
Diet / lifestyle only		124	17.7
Oral medication		338	48.3
Insulin		227	32.2
Non-insulin injectables		11	1.6
Co-morbidities	705	2.6	2.2

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Table 2 Main Study Variables Descriptive Statistics

	N	***Mean / n***	***SD / %***
Depressive symptoms			
PHQ-9 total	705	6.6	6.0
Moderate-to-severe depressive symptoms			
(PHQ-9 total ≥10)		195	28
Body mass index	705	32.6	7.8
Weight Status	705		
Underweight		3	0.4
Healthy weight		70	9.9
Overweight		214	30.4
Obese		418	59.3
Physical Activity	705		
Low		203	28.8
Medium		237	33.6
High		265	37.6

501 **Table 3 Depressive Symptoms by Volume of Physical Activity (Unadjusted ANCOVA)**
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	SS	df	MS	F	*P*	η_p^2
Whole Sample						
Volume of Physical						
Activity	1577.60	2	788.80	23.66	<0.001	0.06
Error	23403.63	702	33.34			
Total	55546.00	705				
R^2= .06 (Adjusted R^2= .06)						
Healthy Weight						
Volume of Physical						
Activity	229.77	2	114.89	3.76	0.028	0.10
Error	2047.72	67	30.56			
Total	4384.00	70				
R^2= .101 (Adjusted R Squared = .074)						
Overweight						
Volume of Physical						
Activity	309.10	2	154.55	5.49	0.005	0.05
Error	5941.71	211	28.16			
Total	12463.00	214				
R^2= .05 (Adjusted R^2= .04)						
Obese						
Volume of Physical						
Activity	863.96	2	431.98	12.06	<0.001	.06
Error	14867.30	415	35.83			

Total	38426.00	418

R^2= .06 (Adjusted R^2= .05)

MS = Mean Square; SS = Sum of squares

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506 **Table 4 Depressive Symptoms by Volume of Physical Activity (ANCOVA adjusted for**
507 **covariates)**

	SS	df	MS	F	*P*	η_p^2
Whole Sample						
Volume of Physical						
Activity	650.78	2	325.39	11.81	<0.001	0.04
Error	16910.76	614	27.54			
Total	48577.00	624				
R^2 = .23 (Adjusted R^2 = .22)						
Healthy Weight						
Volume of Physical						
Activity	157.56	2	77.78	3.40	0.041	0.11
Error	1250.96	54	23.17			
Total	3943.00	63				
R^2= .38 (Adjusted R^2= .29)						
Overweight						
Volume of Physical						
Activity	188.77	2	94.37	3.78	0.025	0.04
Error	4525.66	181	25.00			
Total	11217.00	190				
R^2= .19 (Adjusted R^2= .16)						
Obese						
Volume of Physical						
Activity	295.52	2	147.76	4.98	0.007	0.03
Error	10659.54	359	29.69			

Total	33144.00	368

R^2= .23 (Adjusted R^2= .21)

MS = Mean Square; SS = Sum of squares

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